S. Kamefuchi and Y. Takahashi

'A generalization of Field Quantization and Statistics' Nuclear Physics 36 (1962) 177-206

Considers commutation properties for Schrodinger field with Hamiltonian $H = \frac{1}{4m}\int(\nabla\psi^{+}\nabla\psi \mp \nabla\psi\nabla\psi^{+})d^3x$

$\Rightarrow \quad \frac{1}{2}\sum E_k(a_k^{+}a_k \mp a_k a_k^{+})$

This paper is referred to by Kamefuchi & Strathdee (1963 as Part I)

E.P. Wigner 'Relativistic Invariance and Quantum Phenomena' RMP 29 (1957) 255-268

gives argument why spin // momentum is an invariant a.m.
for the photon, but not for massive particles.
+ves - helicity gives 2 states for polarization
= (2s+1) for $s = \frac{1}{2}$ and massless neutrinos of sole helicity (cf Wightman (1962)

T.D. Newton & E.P. Wigner 'Localized States for Elementary Systems' RMP 21 (1949) 400-406, use Bargmann-Wigner states to determine its localized states

H. Feshbach & F. Villars

'Elementary Relativistic Wave Mechanics of Spin 0 and Spin ½ Particles' RMP 30 (1958) 24-45.
refers to Kemmer PRS. A 173 (1939) 91
for treatment of K.-G. eqn.
This is derived by Kemmer from his β-matrix approach.

K.M. Case 'Some Generalizations of the Foldy-Wouthuysen transformation' PR. 95 (1954) 1323-1328
~~applies~~ develops position operator for a spin 0 particle based on β-matrix formalism (essentially). Very clear treatment — much mathematically clearer even tho F.W. transformation — cf ~~[illegible]~~ Feshbach, Villars (1958) who do not refer to Case's important paper

J. J. Giambiagi 'Analogy between Lorentz and Foldy-Wouthuysen transformations'
N.C. ~~14~~ 16 (1960), 202.
Short note showing formal analogy between Lorentz transformation, F.W. transformation

R.H. Good and M.E. Rose
'Relation between F-W and Lorentz transformations'
N.C. 24 (1962) 864-869. develops the idea

L.L. Foldy 'Synthesis of Covariant Particle Equations'
P.R. 102 (1956) 568-581
says on p 568 'the known (sic) relation of the F-W representation to the Wigner Bargmann reps of the proper inhomogeneous Lorentz group.

R.J. Glauber 'Coherent and Incoherent States of the Radiation Field' PR 131 (1963) 2766-2788
gives v. clear discussion of aspects of a for oscillator & relation to moving wave-packet soln of Schrodinger.

Glauber refers to mathematical representation of oscillator states by Bargmann (cf Javet)

Glauber does not consider eigenstates of $a+a^{+}$ $(=q)$ b/c not non-normalizable?

C. Fronsdal 'Unitary Irreducible Representations of the Lorentz Group' P.R. 113 (1959) 1367–1374 explicitly shows how to go from Wigner's states to covariant states by inverse F.W. transformation, after 'doubling' the Wigner states.

L.L. Foldy 'Synthesis of Covariant Particle Eqns' P.R. 102 (1956) 568–581 says, p. 580. "If in one Lorentz frame particle is localized at the point r=0 at t=0 then in another frame the same state will not be localized, but spread out in space. ..... but it implies no lack of relativistic covariance in the theory!

Earman. Rationality & Foundations of Scientific Inference

reception — Earman me

Bayesian retreats

(a) constraints
(b) Washing out priors
(c) Representational soln
(d) Evolutionary soln
(e) Socialism — aggregation
(f) Modest realism
(g) Non-Bayesian
(h) Retrenchment -

References on PCT Theorem from Luders & Zumino P.R. 106 (1957) 385

J. Schwinger P.R. 82 (1951) 914 — also refers to connection between spin & statistics.
91 (1953) 713

G. Lüders: Kgl. Danske Videnskab. Selskab Mat-fys Medd 28 no 5 (1954)

W. Pauli in Niels Bohr and the Development of Modern Physics (ed. W Pauli) 1955

TCP follows from invariance under proper Lorentz group alone. — see also.

J. S. Bell Proc. Roy Soc. A 231 (1955) 79.

R. Jost. Helv. Phys Acta 30 (1957) 409 (for general proof of TCP.

G. Lüders Ann Phys 2 (1957)).

References on QFT

Wave equations

✓K. M. Case P.R. 95 (1954) 1323

✓L.L. Foldy P.R 102 (1956) 568.

✓C. Fronsdal P.R. 113 (1959) 1367

Fonda, Ghirardi P.R 175 (1968) 2082

✓R. Jost The General Theory of Quantized Fields (1965)

J. J. Sakurai Ann. Phys 11 (1960) 1, Gauge Theories

spin statistics

✓W. Pauli P.R. 58 (1940) 716.

G. Lüders & B. Zumino P.R. 110 (1958) 1450 ([illegible] Bosons)

✓G.F. Dell'Antonio Ann. Phys. 16 (1961) ~~1054~~ 153

✓H. Araki J. Math. Phys. 2 (1961) 267

✓N. Burgoyne N.C. 8 (1958) 607

PCT Theorem

✓G. Lüders Ann Phys. 2 (1957) 1

✓G. Lüders & B. Zumino P.R. 106 (1957) 385 (short note on application of TCP)

S. Weinberg P.R. 133 B (1964) 1318

134 B (1964) 882 (m=0 states)

✓ H. Umezawa Quantum Field Theory (1956)

E. Wigner & V. Bargmann Proc. Nat. Ac. Sciences 34 (1948) 211 – 223
'Group Theoretical Discussion of Relativistic wave equations'

Coherent States

✓ R.J. Glauber: P.R. 131 (1963) 2766.

✓ J. Mulvey (ed.) The Nature of Matter (1981).

✓ A. Pickering Constructing Quarks (1981)

✓ Higher spins Takahashi in Boulder lectures Vol. X,A p. 351 – 431 1968.
('Quantization of Higher Spin Fields')

Casimir Effect

✓ Boyer: Ann. Phys. 56 (1970) 474

✓ ~~Bali~~ Balian & Duplantier Ann. Phys. 112 (1978) 751

Localization operators

✓ Barut & Malin. R.M.P. 40 (1968) 632.
(Extra conditions on N–W operators only satisfied for scalar fields?).

Bohr – Rosenfeld paper in Boston Studies vol.

Geometrodynamics in PSA 1972 (Boston Studies)
C. Misner, J. Stachel etc.

N.D. Birrell and P.C.W. Davies

Quantum Fields in Curved Space. CUP (1982)

C. Isham, R. Penrose and D. Sciama (eds)

Quantum Gravity 2., OUP. (1982)

✓ R. Haag: Dan. Mat. Fys. Medd. 29 no 12 (1955)

Haag's theorem + asy S-matrix ≡ field theory.

'On Quantum Field Theories'.

P. Roman Introduction to Quantum Field

Theory: John Wiley, Son. 1969.

Normalised commutation relations are not fixed.

✓ P. Van Nieuwenhuizen 'Supergravity'.

Physics Reports 68 (1981) 189-398.

✓ D.Z. Freedman and P. van Nieuwenhuizen

'Supergravity and the Unification of the Laws of

Physics' Scientific Am. 238 no 2 (1978) 126 - 143

S. Weinberg   Notes for Hist QFT   Daedalus 106 (1977) 17.

'To the best of my knowledge, there does not exist anything like a full history of the past 50 years of QFT. -- This is a pity, not only because of the fundamental nature of QFT, but also because its history offers an interesting insight to the nature of scientific advance.

In QFT 'the essential element of progress has been the realization, again & again, that a revolution is unnecessary'

'There is no branch of natural science which is so abstract, so far removed from everyday notions of how nature behaves as QFT'.

'It is not the natural or the social or cultural setting that has determined the direction of research in physics, but rather the logic of the subject itself, the need to understand nature as it really is'

'A great deal of work needs to be done by professional historians of science in uncovering the story of the last ½-century of theoretical physics & PTO

I would be delighted if this article were to spur someone to take on this needed task.

the central dogma of QFT: the essential reality is a set of fields subject to the rules of SR & QM; all else is derived as a consequence of the quantum dynamics of these fields.

Dirac resisted idea that QFT is needed for particles other than photons.

; the great thing accomplished by the ~~theory~~ discovery of the Lamb Shift was not so much that it forced us to change our physical theories, as that it forced us to take them seriously!

Disenchantment in 1950's due to nonrenormalizable (weak interactions) and no appropriate scheme for strong interactions.

Modern picture represents a nearly complete triumph of the field over the particle view of matter: the fundamental entities are the quark & gluon fields which do not correspond to any particles that can be observed even in principle, whereas the observed strongly interacting particles are not elementary at all but are mere consequences of an underlying QFT.

Moyer St. Hs. Phil Sci vol 9

Evolution of Thomson, Tait Treatise on Natural Philosophy (1867)

Based on doctrine of energy as fundamental although this was regarded as embodied in material system (matter etc).

Contrast Einstein who first attained the field.

M.J Klein continues 'Mechanical Explanation —!

quotes Einstein Autobiographical Notes, Schilpp 25, 27

'one got used to operating with these fields as independent substances without finding it necessary to give oneself an account of their mechanical nature!'

— Some discussion of energetists, Ostwald, Helm etc.

Whyte Nature review of Larmor's Aether & Matter

Larmor gave up mechanical models of aether in 'Aether & Matter' → aether is an immaterial medium sui generis not composed of identifiable elements with definite locations in absolute space.

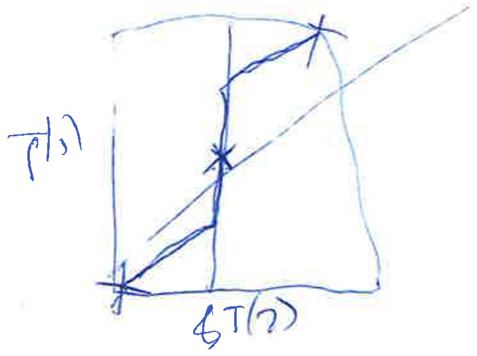
D.F. Moyer SI-HPS. vol. 9. Continuum Mechanics & Field Theory.
refers to Einstein 'Maxwell's Influence on the Development of the Conceptions of Physical Reality' in Sir J.J. Thomson et al. James Clerk Maxwell (Cambridge: CUP) 1931, pp. 66-73.
Conceptions of field also as the ultimate physical reality advanced by Faraday, and by Maxwell; Thomson however thought of the field as a material continuum generalized dynamics but 'hidden machinery' assumed to exist.
cp. em. theory of ~~matter~~ & mechanics of Lorentz.

R. McCormmach Isis (1970) Lorentz's em. view of nature

p.459 Mech. view exp. ultimate constituents of physical reality as discrete, or, sometimes, continuous inertial masses, and that they move according to the laws of mechanics under the influence of distant or contact forces.

Em. view of nature exp. ultimate physical realities are e.m. ether and electric particles. These latter may be structures in the ether which is sole reality (cf. Larmor). Ether, charge for Lorentz are nonmechanical entities (the basic physical entities). Contact law with Maxwell.

Charged particles are in part mechanical bodies with inertial mass, weight, charge is unexplained – Later view of Lorentz, Wien, Abraham. [illegible] was that all mass is em. in origin but Abraham showed non-elm. forces must also be present on the electron. Mie thought it just that electrons were singularities in the ether – later regions of high field intensity where Maxwell's eqs no longer hold ⇒ non linear electrodynamics. Initially regarded Hilbert's theory of GR as fulfilling the role of ether of the older electron theory (Einstein commented on this)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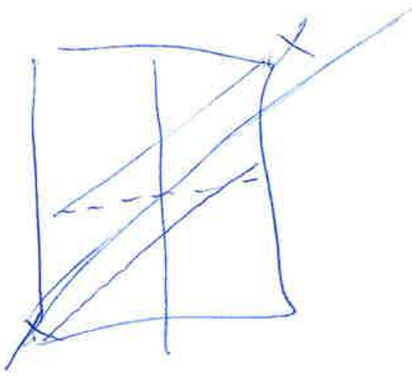

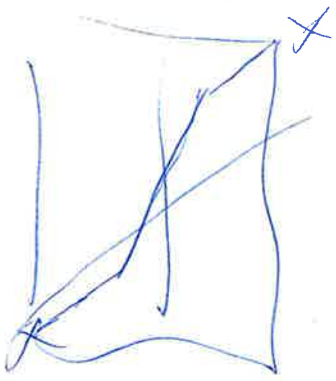

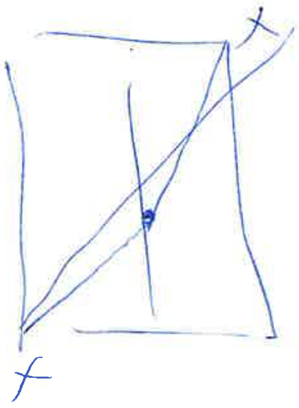

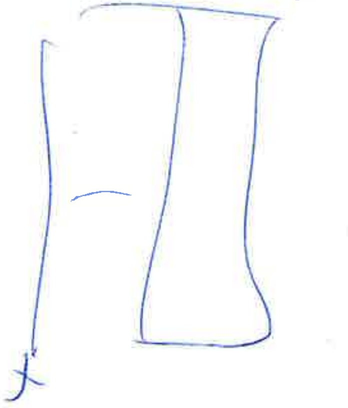

Volkov
JETP 9 (1959) 1107

writes for Dirac field

$$\bar{E} = i\int\left(\bar{\psi}\gamma_4\psi - \frac{\partial}{\partial t}\psi\gamma_4^T\bar{\psi}\right)dV.$$

$$\rightarrow \sum_p |p_0|\left(a_p^+ a_p - a_p a_p^+\right) + \left(b_p^+ b_p - b_p b_p^+\right)$$

on applying Fourier expansion

as against $E = i\int\bar{\psi}\gamma_4\psi$.

$\bar{E}$ is charge symmetrized (Volkov does not say this but I am sure this is the reason) cp Schwinger's original papers.

Volkov gives reference to Akhiezer & Berestetskii Quantum Electrodynamics for the information.

V. also writes $Q = e\int\left(\bar{\psi}\gamma_4\psi - \psi\gamma_4^T\bar{\psi}\right)dV$

X

29618

P.A. 89/90 2785

Personal allowances.

$$a^{+}a$$

$$= \frac{1}{2}\left(a^{+}a - a a^{+} - 1\right)$$

$$\left[a_i, \left(a_j^{+}a_j - a_j a_j^{+}\right)\right]$$

$$\left[a_i, a_j^{+}a_j\right] = a_i$$

$$= a_i a_j^{+} a_j - a_j^{+} a_j a_i$$

$$= \left(\delta_{ij} - a_j^{+} a_i\right) a_j - a_j^{+} a_j a_i$$

$$= \delta_{ij} a_j - a_j^{+} a_i a_j + a_j^{+} a_i a_j$$

$$\left(\delta_{ij} + a_j^{+} a_i\right) a_j - a_j^{+} a_j a_i$$

$$= \delta_{ij} a_j$$

$|\bar{0}\alpha\rangle = \sum c_n |n\rangle$

$n \to n+1$

$\bar{a}|0\alpha\rangle = \sum c_n \sqrt{n}\,|n-1\rangle.$

$= -\alpha \sum c_n |n\rangle.$

$c_{n+1}\sqrt{n+1}. = -\alpha\, c_n.$

$|0\alpha\rangle = \sum_{n=0}^{\infty} c_n |n\rangle$

$n-1 = m$

$n = m+1$

$a|0\alpha\rangle = \sum_{n=0}^{\infty} c_n \sqrt{n}\,|n-1\rangle$

$n = m-1$

$m = 1+n.$

$= -\alpha \sum_{n=0}^{\infty} c_n |n\rangle$

$= -\alpha\, c_0 |0\rangle$

$\therefore \sum_{n=0}^{\infty} c_{n+1}\sqrt{n+1}\,|n\rangle. = -\alpha \sum c_n |n\rangle.$

$\therefore c_{n+1} = -\frac{\alpha}{\sqrt{n+1}}\cdot c_n$

$= \frac{-\alpha^2}{\sqrt{n+1, m}}\, c_{n-1} = \frac{(-\alpha)^n}{\sqrt{n!}}$

A $c_n = \frac{-\alpha}{\sqrt{n}}\cdot c_{n-1} = \frac{-\alpha^n}{\sqrt{n!}},\ c_0.$

$|0\alpha\rangle = c_0 \sum \frac{-\alpha^n}{\sqrt{n!}} |n\rangle$

$\langle\ \rangle = |c_0|^2 = \sum \frac{-\alpha^n}{\sqrt{n!}} = e^{-|\alpha|^2}$

$\therefore c_0 = e^{-1/2|\alpha|^2}$

So $\underline{|0\alpha\rangle = \sum |n\rangle \frac{(-\alpha)^n}{n!} e^{-\frac{1}{2}\alpha^2}}$

①

$(a_k + a_k^{+})|q\rangle = q\,|q\rangle$

$a_k|n\rangle = \sqrt{n}|n-1\rangle$
$a_k^{+}|n\rangle = \sqrt{n+1}\,|n+1\rangle$

Expand $|q\rangle = \sum_{n=0}^{\infty} c_n\,|n\rangle$

Then $\sum_{n=0}^{\infty} c_n\left\{\sqrt{n}\,|n-1\rangle + \sqrt{n+1}\,|n+1\rangle\right\}$

$= q\sum_{n=0}^{\infty} c_n\,|n\rangle$

$\boxed{n-1 = n'}$ $n+1 = n'$

equate. $\sum_{n=0}^{\infty} c_{n+1}\sqrt{n+1}\,|n\rangle$

$+ \sum_{n=1}^{\infty} c_{n-1}\sqrt{n}\,|n\rangle$

$\therefore\ ^{*}\ c_{n+1}\sqrt{n+1} + c_{n-1}\sqrt{n} = q\cdot c_n \quad , n = 1, 2, 3$

~~A c_{n+1}~~ ad

$c_1\,|0\rangle = q\,c_0\,|0\rangle$

So $c_1 = q\,c_0$

For * gives

$n=1,\quad c_2\sqrt{2} + c_0 = q\,c_1$

$n=2\quad c_3\sqrt{3} + c_1\sqrt{2} = q\,c_2$

$n=3\quad c_4\sqrt{4} + c_2\sqrt{3} = q\,c_3$

$\frac{1}{\sqrt{2}} + \sqrt{2}$
$= \sqrt{2}\cdot 3/2 = 3/\sqrt{2}$

So $c_1 = q\,c_0$

$c_2\sqrt{2} + c_0 = q\,c_1 = q^2 c_0$

$\therefore c_2 = \frac{1}{\sqrt{2}}(q^2-1)\,c_0$

$c_3 = \left(\frac{1}{\sqrt{2}}q(q^2-1) - q\sqrt{2}\right)\frac{1}{\sqrt{3}}\,c_0$

$= \frac{1}{\sqrt{3}}\left(\frac{1}{\sqrt{2}}q^3 - \frac{3q}{\sqrt{2}}\right)c_0 = \frac{1}{\sqrt{3\cdot 2}}(q^3 - 3q)\,c_0$

unit $q=0$

$c_1 = 0$

$c_2 = -\frac{1}{\sqrt{2}} c_0$

$c_3 = 0$

$c_4 = -\sqrt{3/4}\, c_2 = \frac{1}{\sqrt{2}} \sqrt{3/4}\, c_0$

So $|q=0\rangle = c_0\left[|0\rangle \frac{1}{\sqrt{2}}|2\rangle + \frac{1}{\sqrt{2}} \cdot \sqrt{3/4}\,|4\rangle + \cdots\right]$

So for normalization

$$|c_0|^2\left(1 + \frac{1}{2} + \frac{3}{8} + \cdots \frac{n}{n+1} \cdot \frac{n-2}{n-1} \cdot \frac{n-4}{n-3} \cdots \frac{1}{2} + \cdots\right) = 1$$

$$U_{n+1} = \frac{n}{n+1} \cdot \frac{n-2}{n-1} \cdots 1/2$$

and $$U_{n+3} = \frac{n+2}{n+3} \cdot \frac{n}{n+1} \cdots 1/2$$

$$\therefore \frac{U_{n+3}}{U_{n+1}} = \frac{n+2}{n+3}$$

References: M. L. G. Redhead

G. W. MACKEY:
Induced Representations of Groups and
Quantum Mechanics 1968

A. KIRILLOV:
Elements of the theory of representations
1976

Y. OHNUKI :
Unitary Representations of the Poincaré
Group and Relativistic Wave Equations 1988.

H. UMEZAWA :
Quantum Field Theory 1954(?)

E. CORSON
Introduction to Tensors, spinors and
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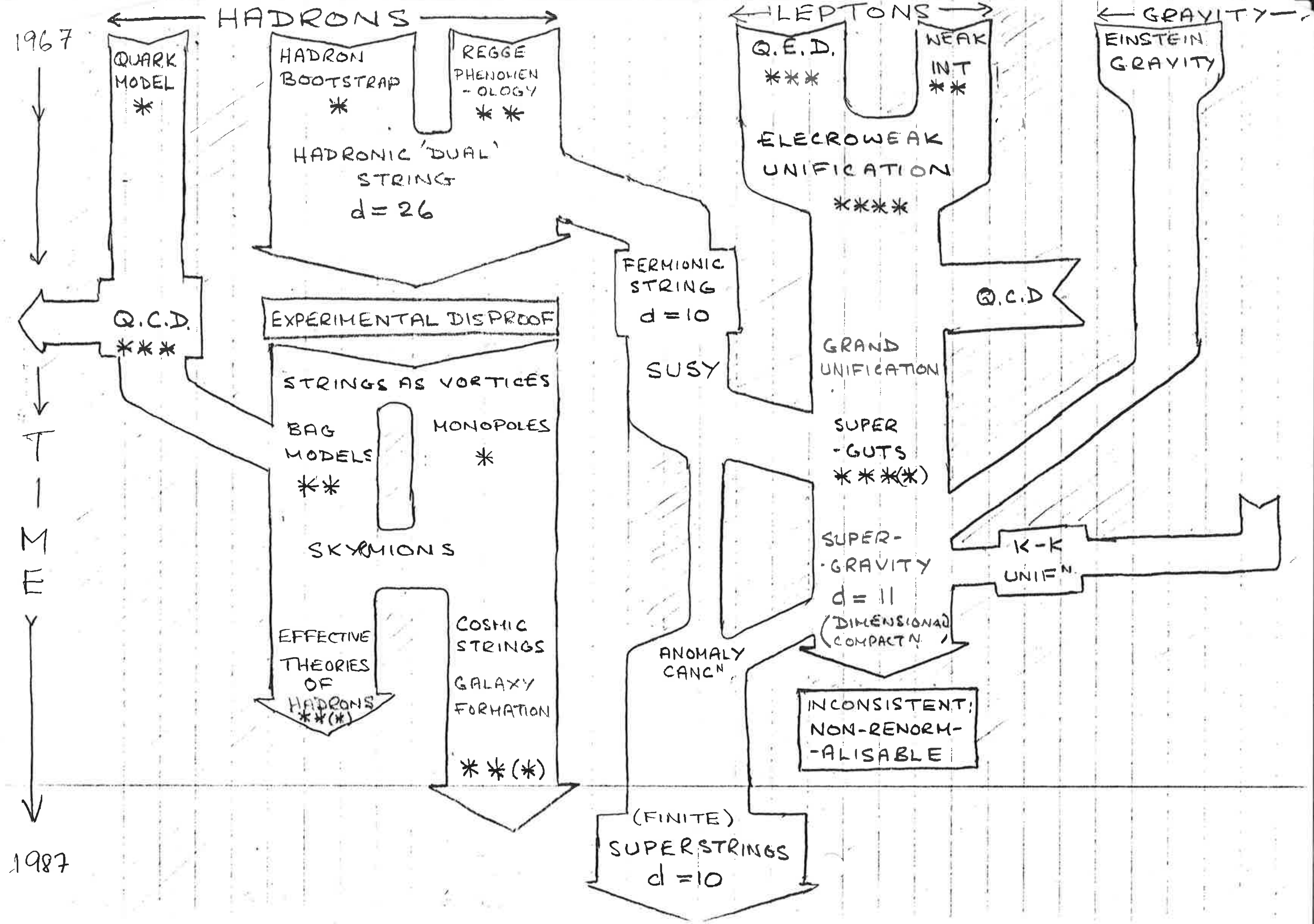
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SUPER-GUTS ***(*)
SUPER-GRAVITY d=11
(DIMENSIONAL COMPACTN.)
INCONSISTENT; NON-RENORM-ALISABLE
EINSTEIN GRAVITY
K-K UNIFN.

QFT Book contd

Introduction

Dirac 1927 paper, photons + massive particles
S. Eq for photons ?

N-particle S. Eq.

$$\left[\sum_{i=1}^{N}\left[\left(-\frac{\hbar^2}{2m}\nabla_i^2\right)+V(\mathbf{r}_i)\right]+\cancel{\sum_{i=1}^{N}\sum_{j}U(\mathbf{r}_i,\mathbf{r}_j)}\right.$$

$$\left.+\sum_{\substack{\cancel{j>i}\\ j=i+1}}^{N}\sum_{i=1}^{N}U(\mathbf{r}_i,\mathbf{r}_j)\right]\Psi(\mathbf{r}_1,\mathbf{r}_2\cdots\mathbf{r}_3;t)$$

$$= i\hbar\,\partial\,\Psi(\mathbf{r}_1,\mathbf{r}_2\cdots\mathbf{r}_N;t)$$

where $\nabla_i^2=\frac{\partial^2}{\partial x_i^2}+\frac{\partial^2}{\partial y_i^2}+\frac{\partial^2}{\partial z_i^2}$.

Second quantized Eq. $\underline{P\Psi = \Psi}$

$$\Psi=\sum_{n_1+n_2+n_3=N}c(n_1,n_2\cdots)\,\Phi(n_1,n_2,n_3\cdots)$$

$$\sum_{i=1}^{N}\left[\underbrace{\left(\quad\right)+V(\mathbf{r}_i)}_{T_i}\right]=\int\Psi^{\dagger}(\mathbf{r})\,T_B\,\psi(\mathbf{r})\,d^3r$$

$$T=-\frac{\hbar^2}{2m}\nabla^2+V(\mathbf{r})$$

$$\sum_{j>i}^{N}\sum_{i=1}^{N}U(\mathbf{r}_i,\mathbf{r}_j)=\frac{1}{2}\iint\psi^{\dagger}(\mathbf{r})\psi^{\dagger}(\mathbf{r}')\,U(\mathbf{r},\mathbf{r}')\,\psi(\mathbf{r})\,\psi(\mathbf{r}')\,d\mathbf{r}\,d\mathbf{r}'$$

$$|X\rangle = |a_1^{s_1}\rangle |a_2^{s_2}\rangle \cdots |a_n^{s_n}\rangle\, |a_N^{s_N}\rangle$$

$s : \{1 \ldots N\} \rightarrow \overset{\cancel{I}}{\{1 \ldots M\}}$ M-dimensional Hilbert space

a^i, $i \in I$ are eigenvalues of A

$$P\,|x\rangle = |a_{p_1}^{s_1}\rangle \cdots |a_{p_n}^{s(n)}\rangle \cdots$$

$$\bar{P}\,|x\rangle = |a_1^{s(p_1)}\rangle \cdots |a_n^{s(p_n)}\rangle$$

or $$P_i|x\rangle = |a_{i_1}^{s(1)}\rangle \cdots |a_{i_n}^{s(n)}\rangle \cdots$$

$$\overline{P_i}\,|x\rangle = \cdots\; |a_n^{s(k)}\rangle \cdots$$

$$\rho|x\rangle = \sum_i P_i|x\rangle \cdot \frac{1}{\sqrt{n_1! n_2! \cdots}\;\sqrt{N!}}$$

~~normalization~~ where n_1 is no of particles in state $s(1)$

n_2 — — — $s(2)$

$$P_i Q_n P_i^{-1} = Q_{i_n} \qquad P_i = \begin{pmatrix} 1 & \cdots & n & \cdots \\ i_1 & i_2 \cdots & i_n & \end{pmatrix}$$

③

$$\left(\sum H_n\right) S|X\rangle$$ where $A = H$.

$|n_1, n_2 \ldots\ldots\rangle$

$$= \sum_n n_n E_n \, S|x\rangle.$$

$$N_n = a_n^{+} a_n. \quad \text{where } [a_1, a_1^{+}] = 1$$

$$\sum H_n \sim \sum_n N_n \int \psi_n^{*}(x) \, H \, \psi_n(x) \, dx.$$

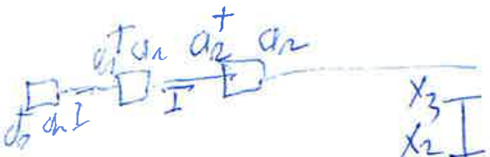
$$= \sum_n \int \Psi_n^{+}(x) \, H \, \Psi(x) \, dx$$

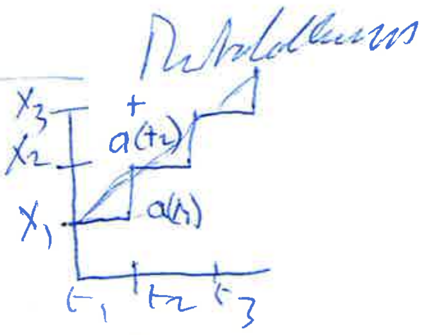
$$\text{where } \Psi(x) = \sum_n a_n \psi_n(x)$$

$$= \sum b_n \psi_n(x)$$

$$I \, S|x\rangle = (a_n^{+} a_n) \, \delta(x)$$

$$I = (a_1^{+} a_1)_n \, (a_1^{+} a_1)_{n-1} \ldots (a_1^{+} a_1)_2 (a_1^{+} a_1)_1$$

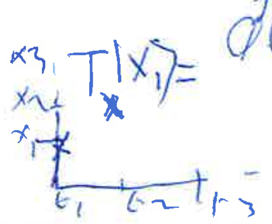

$a_1^{+} a_1$
a_2^{+}
a_2
a_1
a_1
I
I


Rutaldums
x_3
x_2
x_1
$a^{+}(t_2)$
$a(t_1)$
t_1
t_2
t_3

$$\psi(x) = \langle 0 | \psi(x) \, a_p^{+} | 0 \rangle$$

$$= \langle \psi(x) \, a_p^{+} \rangle_0 = e^{-ipx}$$

$$a a^{+} = N + 1$$


a unit time atoms
x_3
x_2
x_1
t_1
t_2
t_3

$$T|x_1\rangle = a^{+}(x_2) \ldots a(t_3) a^{+}(t_3) a(x_2) a^{+}(t_2) a(t_1) |x_1\rangle$$

$$T|x_1\rangle = a(t_3) a^{+}(t_2) a(t_2) a^{+}(t_1) |x_1\rangle$$

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